

## Claims

1. A battery capacity calculating method for calculating a residual capacity and/or residual power of a secondary battery, comprising:
  - 5 an equilibrium voltage curve calculating step for calculating an equilibrium voltage curve  $C_{equ}$  showing a relation between a discharged capacity and an equilibrium voltage in said secondary battery;
    - a voltage current measuring step for measuring a terminal voltage  $V_{mea}$  and a current value  $I$  of said secondary battery at a time of discharging;
    - 10 a discharged capacity calculating step for calculating a discharged capacity  $Q_{mea}$  of said secondary battery based on the terminal voltage  $V_{mea}$  and the current value  $I$ , both measured at said voltage current measuring step;
      - an apparent equilibrium voltage calculating step for calculating an apparent equilibrium voltage  $V_{ocv}$  by adding a voltage drop  $\Delta V_{dc}$  by a direct current resistance
      - 15  $R_{dc}$  to the terminal voltage  $V_{mea}$ ;
        - an apparent discharged capacity calculating step for calculating an apparent discharged capacity  $Q_{ocv}$  corresponding to the apparent equilibrium voltage  $V_{ocv}$  calculated at said equilibrium voltage calculating step based on the equilibrium voltage curve  $Q_{equ}$  calculated at said equilibrium voltage curve calculating step;
        - 20 a capacity shift calculating step for calculating a capacity shift  $\Delta Q$  being a difference between the discharged capacity  $Q_{mea}$  and the apparent discharged capacity  $Q_{ocv}$ ; and
          - an estimating step for estimating a discharge curve  $C_{pre}$  in a future based on the capacity shift  $\Delta Q$  calculated at said capacity shift calculating step.
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  2. The battery capacity calculating method according to claim 1, wherein at said estimating step, when a state of said battery is close to the last stage of discharging, a reduction rate  $dQ$  of a capacity shift to a discharged capacity is calculated based on the discharged capacity  $Q_{mea}$  calculated at said discharged capacity calculating step and
    - 30 the capacity shift  $\Delta Q$  calculated at said capacity shift calculating step, and the discharge curve  $C_{pre}$  in the future is estimated based on the capacity shift  $\Delta Q$  and the

reduction rate  $dQ$ .

3. The battery capacity calculating method according to claim 2, wherein the capacity shift  $\Delta Q$  is expressed by a linear function of the discharged capacity  $Q_{\text{mea}}$  when the state of said battery is close to the last stage of discharging.
4. The battery capacity calculating method according to claim 1, wherein at said estimating step, when a state of said battery is not in the last stage of discharging, the equilibrium voltage  $V_{\text{equ}}$  corresponding to the discharged capacity  $Q_{\text{mea}}$  is calculated based on the equilibrium voltage curve  $C_{\text{equ}}$ , and the discharge curve  $C_{\text{pre}}$  in the future is estimated based on the voltage drop  $\Delta V$  being the difference between the equilibrium voltage  $V_{\text{equ}}$  and the terminal voltage  $V_{\text{mea}}$ .
5. The battery capacity calculating method according to claim 4, wherein at said estimating step, the discharge curve  $C_{\text{pre}}$  is estimated by subtracting the voltage drop  $\Delta V$  from the equilibrium voltage curve  $C_{\text{equ}}$ .
6. The battery capacity calculating method according to claim 4, wherein at said estimating step, the discharge curve  $C_{\text{pre}}$  is estimated using a maximum voltage drop  $\Delta V_{\text{max}}$  corresponding to a maximum load by present in place of the voltage drop  $\Delta V$ .
7. The battery capacity calculating method according to claim 1, further comprising a residual capacity/residual power calculating step for calculating the residual capacity and/or the residual power of said secondary battery based on the discharge curve  $C_{\text{pre}}$  estimated at said estimating step.
8. The battery capacity calculating method according to claim 1, further comprising a step for performing a judgment whether a state of said battery is near the last stage of discharging or not based on the apparent equilibrium voltage  $V_{\text{ocv}}$  to switch an estimating method of the discharge curve  $C_{\text{pre}}$  according to a judgment result.

9. The battery capacity calculating method according to claim 8, wherein at said switching step, the apparent equilibrium voltage  $V_{ocv}$  is compared with a predetermined threshold value to perform the judgment whether the state of said battery is near the last stage of discharging or not.

10. The battery capacity calculating method according to claim 1, wherein at said apparent equilibrium voltage calculating step, the direct current resistance  $R_{dc}$  is calculated based on voltage changes according to current changes.

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11. The battery capacity calculating method according to claim 1, wherein at said apparent equilibrium voltage calculating process, the direct current resistance  $R_{dc}$  is calculated based on an average voltage and an average current value.

12. The battery capacity calculating method according to claim 1, wherein at said equilibrium voltage curve calculating step, the equilibrium voltage curve  $C_{equ}$  is calculated based on equilibrium voltages at at least two points and a capacity between the equilibrium voltages.

13. The battery capacity calculating method according to claim 12, wherein at said equilibrium voltage curve calculating step, a shrinkage ratio  $S$  expressed by a quotient obtained by dividing a fully charged capacity of the secondary battery by a fully charged capacity of an initial battery which is not deteriorated based on the equilibrium voltages at the at least two points and a capacity between the equilibrium voltages.

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14. The battery capacity calculating method according to claim 1, wherein at said equilibrium voltage curve calculating step, charging is compulsorily stopped and an equilibrium voltage is obtained based on a subsequent voltage change.

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15. The battery capacity calculating method according to claim 1, wherein at said

residual capacity/residual power calculating step, the calculated residual capacity and/or the calculated residual power are transmitted to an electronic apparatus using said secondary battery as its power supply.

- 5 16. A battery capacity calculating apparatus for calculating a residual capacity and/or residual power of a secondary battery, comprising:
  - voltage measuring means for measuring a terminal voltage  $V_{\text{mea}}$  of said secondary battery at a time of discharging;
  - current measuring means for measuring a current value  $I$  of said secondary
  - 10 battery at the time of discharging; and
  - operation processing means for calculating the residual capacity and/or the residual power of said secondary battery,
  - wherein said operation processing means calculates an equilibrium voltage curve  $C_{\text{equ}}$  showing a relation between a discharged capacity and an equilibrium
  - 15 voltage in said secondary battery, calculates a discharged capacity  $Q_{\text{mea}}$  of said secondary battery based on the terminal voltage  $V_{\text{mea}}$  measured with said voltage measuring means and the current value  $I$  measured with said current measuring means, calculates an apparent equilibrium voltage  $V_{\text{ocv}}$  by adding a voltage drop  $\Delta V_{\text{dc}}$  by a direct current resistance  $R_{\text{dc}}$  to the terminal voltage  $V_{\text{mea}}$ , calculates an apparent
  - 20 discharged capacity  $Q_{\text{ocv}}$  corresponding to the apparent equilibrium voltage  $V_{\text{ocv}}$  based on the equilibrium voltage curve  $Q_{\text{equ}}$ , calculates a capacity shift  $\Delta Q$  being a difference between the discharged capacity  $Q_{\text{mea}}$  and the apparent discharged capacity  $Q_{\text{ocv}}$ , and estimates a discharge curve  $C_{\text{pre}}$  in a future based on the capacity shift  $\Delta Q$ .
- 25 17. The battery capacity calculating apparatus according to claim 16, wherein, when a state of said battery is close to the last stage of discharging, said operation processing means calculates a reduction rate  $dQ$  of a capacity shift to a discharged capacity based on the discharged capacity  $Q_{\text{mea}}$  and the capacity shift  $\Delta Q$ , and estimates the discharge curve  $C_{\text{pre}}$  in the future based on the capacity shift  $\Delta Q$  and the
- 30 reduction rate  $dQ$ .

18. The battery capacity calculating apparatus according to claim 17, wherein the capacity shift  $\Delta Q$  is expressed by a linear function of the discharged capacity  $Q_{\text{mea}}$  when the state of said battery is close to the last stage of discharging.
- 5 19. The battery capacity calculating apparatus according to claim 16, wherein, when a state of said battery is not in the last stage of discharging, said operation processing means calculates the equilibrium voltage  $V_{\text{equ}}$  corresponding to the discharged capacity  $Q_{\text{mea}}$  based on the equilibrium voltage curve  $C_{\text{equ}}$ , and estimates the discharge curve  $C_{\text{pre}}$  in the future based on the voltage drop  $\Delta V$  being the  
10 difference between the equilibrium voltage  $V_{\text{equ}}$  and the terminal voltage  $V_{\text{mea}}$ .
20. The battery capacity calculating apparatus according to claim 19, wherein said operation processing means estimates the discharge curve  $C_{\text{pre}}$  by subtracting the voltage drop  $\Delta V$  from the equilibrium voltage curve  $C_{\text{equ}}$ .
- 15 21. The battery capacity calculating apparatus according to claim 19, wherein said operation processing means estimates the discharge curve  $C_{\text{pre}}$  using a maximum voltage drop  $\Delta V_{\text{max}}$  corresponding to a maximum load by present in place of the voltage drop  $\Delta V$ .
- 20 22. The battery capacity calculating apparatus according to claim 16, wherein said operation processing means calculates a residual capacity and/or the residual power of said secondary battery based on the estimated discharge curve  $C_{\text{pre}}$ .
- 25 23. The battery capacity calculating apparatus according to claim 16, wherein said operation processing means performs a judgment whether a state of said battery is near the last stage of discharging or not based on the apparent equilibrium voltage  $V_{\text{ocv}}$  to switch an estimating method of the discharge curve  $C_{\text{pre}}$  according to a judgment result.
- 30 24. The battery capacity calculating apparatus according to claim 23, wherein

said operation processing means compares the apparent equilibrium voltage  $V_{ocv}$  with a predetermined threshold value to perform the judgment whether the state of said battery is near the last stage of discharging or not.

5     25.     The battery capacity calculating apparatus according to claim 16, wherein said operation processing means calculates the direct current resistance  $R_{dc}$  based on voltage changes according to current changes.

10     26.     The battery capacity calculating apparatus according to claim 16, wherein said operation processing means calculates the direct current resistance  $R_{dc}$  based on an average voltage and an average current value.

15     27.     The battery capacity calculating apparatus according to claim 16, wherein said operation processing means calculates the equilibrium voltage curve  $C_{equ}$  based on equilibrium voltages at at least two points and a capacity between the equilibrium voltages.

20     28.     The battery capacity calculating apparatus according to claim 27, wherein said operation processing means calculates a shrinkage ratio  $S$  expressed by a quotient obtained by dividing a fully charged capacity of said secondary battery by a fully charged capacity of an initial battery which is not deteriorated based on the equilibrium voltages at the at least two points and a capacity between the equilibrium voltages.

25     29.     The battery capacity calculating apparatus according to claim 16, wherein said operation processing means compulsorily stops charging and obtains an equilibrium voltage based on a subsequent voltage change.

30     30.     The battery capacity calculating apparatus according to claim 16, further comprising transmitting means for transmitting the residual capacity and/or the residual power calculated by said operation processing means to an electronic

apparatus using said secondary battery as its power supply.

31. A battery capacity calculating program capable of being executed by a computer for calculating a residual capacity and/or residual power of a secondary battery, comprising:
  - equilibrium voltage curve calculating processing for calculating an equilibrium voltage curve  $C_{equ}$  showing a relation between a discharged capacity and an equilibrium voltage of said secondary battery;
  - voltage current measuring processing for measuring a terminal voltage  $V_{mea}$  and a current value  $I$  of said secondary battery at a time of discharging;
  - discharged capacity calculating processing for calculating a discharged capacity  $Q_{mea}$  of said secondary battery based on the terminal voltage  $V_{mea}$  and the current value  $I$ , both measured by said voltage current measuring processing;
  - apparent equilibrium voltage calculating processing for calculating an apparent equilibrium voltage  $V_{ocd}$  by adding a voltage drop  $\Delta V_{dc}$  by a direct current resistance  $R_{dc}$  to the terminal voltage  $V_{mea}$ ;
  - apparent discharged capacity calculating processing for calculating an apparent discharged capacity  $Q_{ocv}$  corresponding to the apparent equilibrium voltage  $V_{ocv}$  calculated by said equilibrium voltage calculating processing based on said equilibrium voltage curve  $C_{equ}$  calculated by said equilibrium voltage curve calculating processing;
  - capacity shift calculating processing for calculating a capacity shift  $\Delta Q$  being a difference between the discharged capacity  $Q_{mea}$  and the apparent discharged capacity  $Q_{ocv}$ ; and
  - estimating processing for estimating a discharge curve  $C_{pre}$  in a future based on the capacity shift  $\Delta Q$  calculated by said capacity shift calculating processing.